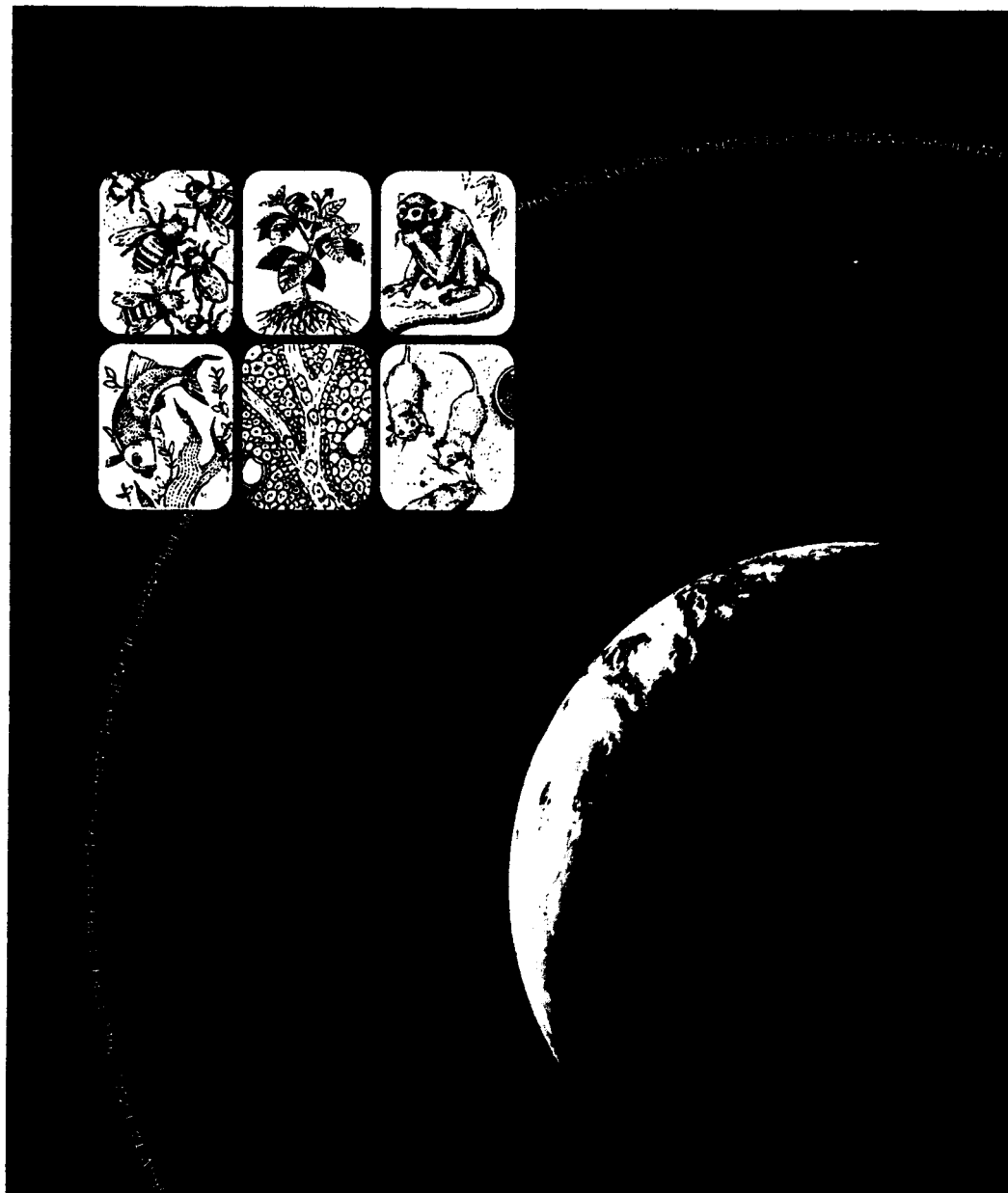


NAS8-35471
DPD 614
DR-4
Requirements



Final Report
Volume II
Appendix D
October 1985

System Analysis Study of Space Platform and Station Accommodations for Life Sciences Research Facilities



(NASA-CR-179273) SYSTEM ANALYSIS STUDY OF
SPACE PLATFORM AND STATION ACCOMMODATIONS
FOR LIFE SCIENCES RESEARCH FACILITIES.
VOLUME 2: STUDY RESULTS. APPENDIX D: LIFE
SCIENCES RESEARCH FACILITY REQUIREMENTS

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SYSTEM ANALYSIS STUDY OF SPACE PLATFORM
AND STATION ACCOMMODATIONS
LIFE SCIENCES RESEARCH FACILITIES

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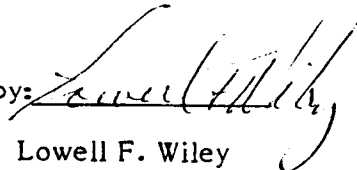
FINAL REPORT
VOLUME II - STUDY RESULTS

APPENDIX D
DI80-27863-2 II


LIFE SCIENCES RESEARCH FACILITY
REQUIREMENTS
October 1985

For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER
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FORWARD

The System Analysis Study of Space Platform and Station Accommodations for Life Sciences Research Facilities (Contract NA58-35471) was initiated May 19, 1983 and completed December 18, 1983. This study was one of two parallel studies conducted for the NASA Marshall Space Flight Center. The Contracting Officer's Representative and Study Manager was Dr. John D. Hilchey.

This study was conducted by the Boeing Aerospace Company, Seattle, WA, and a subcontractor: Technology Incorporated, Houston, TX.

The study final report is contained in three volumes with three appendices attached to Volume II as shown below:

- D180-27863-1 Volume I - Executive Summary
- D180-27863-2 Volume II - Study Results
 - Appendix A - Parametric Analysis Data Package
 - Appendix B - Tradeoff Analysis Data Package
 - Appendix C - Preliminary Conceptual Design Requirements Data Package
- D180-27863-3 Volume III - final Briefing Book

Change Order No. 3 to contract NA58-35471 extended the period of performance through 31 December 1984 and defined statement of work changes. The study results from these changes are reported as Attachment I to Volume II of the Final Report as shown below:

- D180-27863-21 Attachment I - Indepth Trade Analysis

Change Orders 6, 7, and 8 to contract NAS8-35471 defined statement of work changes and extended the period of performance through November 1, 1985. The study results from these changes are reported as Attachment II to Volume II of the Final Report.

Additional appendices have been added to the documentation as shown below:

D180-27863-2II Attachment II - Phase A Conceptual Design and Programmatic

Appendix D - Requirements

Appendix E - Work Breakdown Structure and Dictionary

Appendix F - Conceptual Layouts and Drawings

LIST OF ACRONYMS AND ABBREVIATIONS

100K	Refers to Class 100,000 cleanroom
10K	Refers to Class 10,000 cleanroom
AEM	Animal Enclosure Module
ASE	Airborne Support Equipment
ATMO	Atmosphere Control System (a design function)
BAC	Boeing Aerospace Company
CDG	Concept Development Group
CELSS	Controlled Ecological Life Support System
CER	Cost Estimating Relationships
C.G.	Center of Gravity
CHEM	Chemical Analysis Instrumentation (a design function)
CONF	Confinement System (a design function)
CONS	Consumables (a design function)
DATA	Data Management System (a design function)
DDT&E	Design, Development, Test, and Evaluation
ECLS	Environmental Control Life Support
ECLSS	Environmental Control Life Support System
ECS	Environmental Control System
ELEC	Electrical Power Management System (a design function)
EM	Engineering Model
EMER	Emergency Power System (a design function)

EMU	Extravehicular Mobility Unit
ESE	Experiment Support Equipment (a design function)
EVA	Extravehicular Activity
g	Gravity
GSE	Ground Support Equipment
Host	Refers to Space Station
HVAC	Heating, Ventilation and Air Conditioning
HYG	Hygiene (a design function)
IOC	Initial Operational Capability
IVA	Intravehicular Activity
kbps	Kilobits per second
kg	Kilograms
KSC	Kennedy Space Center
kw	Kilowatts
K\$	Thousands of dollars
LIGH	Illumination (a design function)
LSRF	Life Sciences Research Facility
LM	Logistic Module
m ³	Cubic meters
MICR	Microscopy (a design function)
M.I.T.	Massachusetts Institute of Technology

MMU	Manned Maneuvering Unit
MPS	Materials Processing in Space
MMSE	Multi-mission support equipment
MSFC	Marshall Space Flight Center
O&C	Operations and Checkout
OMV	Orbital Maneuvering Vehicle
OPF	Orbiter Processing Facility
ORU	Orbital Replacement Unit
OTV	Orbital Transfer Vehicle
PI	Principal Investigator
P/L	Payload
RAHF	Research Animal Holding Facility
REFR	Refrigeration (a design function)
RSS	Rotating Service Structure
SIMG	Gravity Simulation (a design function)
SL	Spacelab
SLF	Shuttle Landing Facility
SS	Space Station
STOW	Storage (a design function)
STRU	Structures (a design function)
STS	Space Transportation System
SWST	Solid Waste Management System (a design function)

TDRSS	Tracking and Data Relay Satellite System
THER	Thermal Control System (a design function)
TRAN	Transportability (a design function)
VAB	Vehicle Assembly Building
VPF	Vertical Processing Facility
WBS	Work Breakdown Structure
WWTR	Water Management System (a design function)

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LIFE SCIENCES RESEARCH FACILITY REQUIREMENTS

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this requirements document is to develop the foundation for concept development for the Life Sciences Research Facility (LSRF). These requirements are developed from the perspective of a Space Station laboratory module outfitter. The common module forms the basic laboratory module element. The mainline laboratory subsystem requirements are emphasized and the common module is treated as a primary interface. The document format has been modeled after attachment C4 to the Space Station definition and preliminary design request for proposal.

1.2 FUNCTIONAL FLOW

The life sciences research facility functional flow is shown in figure 1.2-1. This flow defines the top level functional elements required to produce, outfit, and process a facility from initiation of hardware to an operating laboratory on-orbit. The flow was used in the definition of the involvement of various program interfaces each of which generate program and technical requirements and elements of cost.

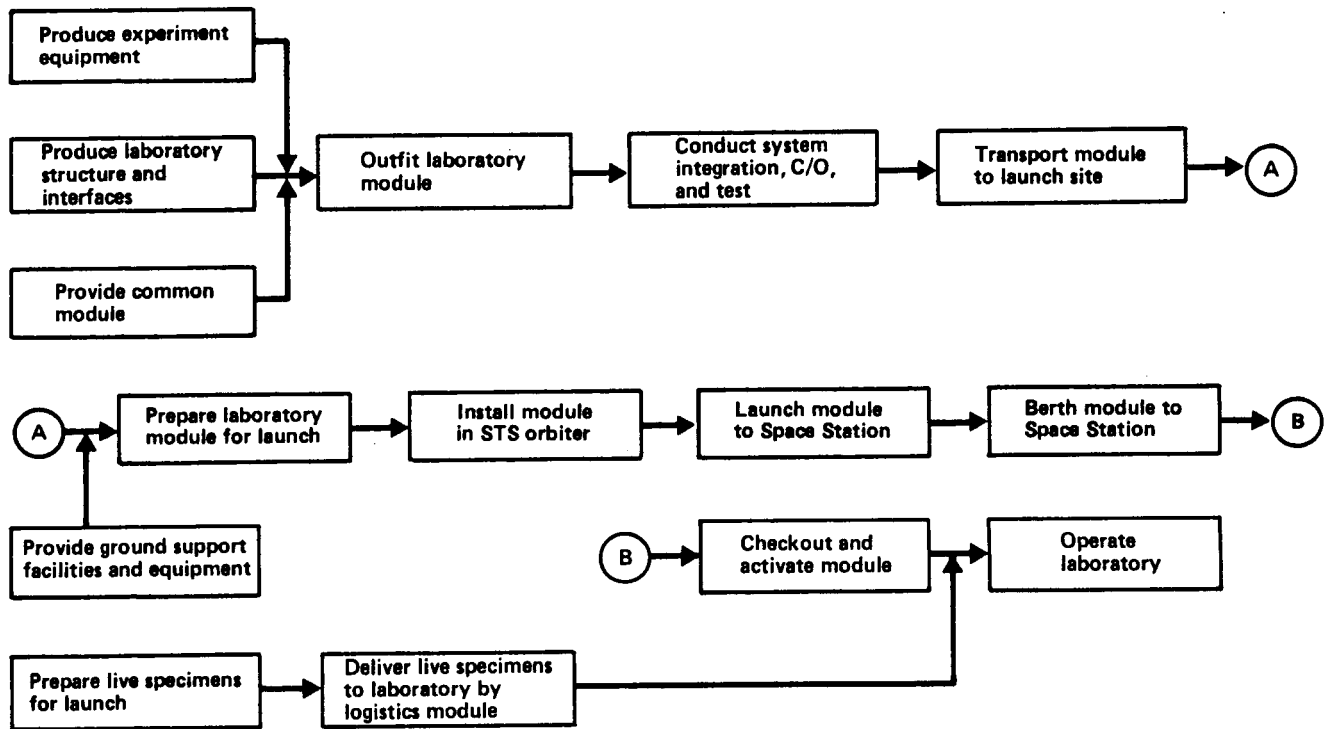


Figure 1.2-1. Top Level Functional Flow

2.0 SCIENCE AND MISSION REQUIREMENTS

The Life Sciences Research Facility is initially planned at IOC to share a laboratory module with the Human Research Laboratory. The mission is defined under mission SAAX-0307 which is an IOC mission with the objective to initially perform the full spectrum of life science research including human, animal, and plant. When an animal and plant vivarium and laboratory are added as mission SAAX-0302, the IOC laboratory module will expand to become a human research laboratory. Figure 2.0-1 displays the phasing of the Space Station life sciences missions.

2.1 EXPERIMENT PROVISION

2.1.1 Laboratory outfitting design shall allow for continued upgrading of experiments and related equipment.

2.1.2 The outfitting design shall provide a user friendly system to facilitate on-board operations by scientist or payload experts with a minimum of space station specialized training.

2.2 SCIENCE REQUIREMENTS

The LSRF shall be equipped to accommodate a wide spectrum of life science research.

2.2.1 Specimen Accommodation (Zero-g)

The LSRF shall provide for the accommodation of live specimens in a zero-g environment.

2.2.1.1 The LSRF shall accommodate specimen holding facilities in the zero-g environment. These facilities include:

- a. Specimen Enclosure
- b. Environmental Control System
- c. Waste Management
- d. Water Management
- e. Nutrient Supply
- f. Monitor and Control Devices
- g. Lights
- h. Video and Instrumentation Monitors

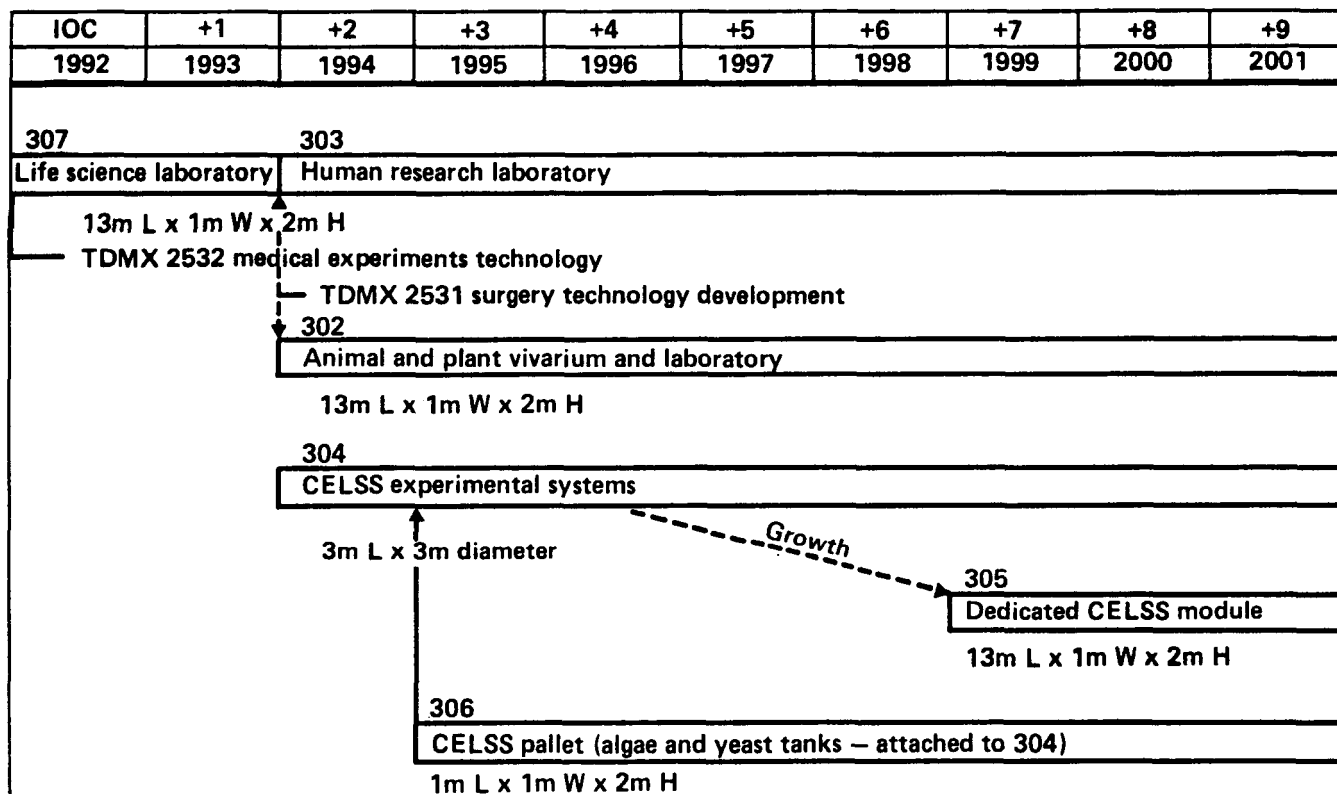


Figure 2.0-1. Life Sciences Missions

2.2.1.2 The zero-g holding facilities shall be capable of supporting specimen types as follows:

- a. Rodents (including breeding)
- b. Small Primates
- c. Large Primates
- d. Plants
- e. Birds
- f. Fish
- g. Frogs
- h. Cell Tissue and Eggs
- i. Algae

2.2.2 Specimen Accommodation (Variable-g)

The LSRF shall provide for the accommodation of live specimens in a variable-g environment.

2.2.2.1 The LSRF shall accommodate specimen holding facilities on rotating devices to achieve artificial gravity conditions of 0.25-g to 1.25-g. These facilities will provide the same functions as stated in para. 2.2.1.1, and support the same specimen types as stated in para. 2.2.1.2.

2.2.3 Live Specimen Transport

Provisions shall be made to adapt the space station logistics module to transport live specimens to and from orbit using holding facilities that supply the life support needs of the specimens during the period of transport to and from orbit.

2.2.4 Research Apparatus

The LSRF shall be capable of accommodating specialized research apparatus for live specimen, short duration studies. These areas of research include rotational and linear accelerations for vestibular studies and metabolic measurement studies.

2.2.5 Laboratory Equipment

Provisions shall be made to provide vertical racks or storage compartments for a variety of laboratory equipment. A representative list follows:

- a. Binocular Microscope
- b. Dissecting Microscope

- c. Laboratory Centrifuge
- d. Specimen Mass Measurement Device
- e. Mass Spectrometer
- f. Spectrophotometer
- g. Gas Chromatograph
- h. Pulmonary Function Analyzer
- i. Bio-Medical Recorder
- j. Oscilloscope
- k. Scintillation Sample Analyzer
- l. Optical Densitometer
- m. PH Analyzer
- n. Blood Gas Analyzer
- o. Drying Oven
- p. Blender
- q. Microprocessor
- r. Biotelemetry system
- s. Animal Physiological Monitoring System
- t. Echocardiograph
- u. Plethysmograph
- v. Radiation Dosimeter
- w. Video Cassette Recorder
- x. Video Camera
- y. Kymograph Camera
- z. Oscilloscope Camera

2.2.6 Cold Storage and Preservation

Provisions shall be made to accommodate cold storage and preservation compartments. These facilities include:

- a. Cold storage refrigeration (+4°C)
- b. Freezer (-70°C)
- c. Cryogenic freezer (-195°C)

2.2.7 Work Benches

The LSRF shall accommodate work benches which allow crewmen to use small laboratory equipment such as a microscope, and for specimen surgery and dissection.

2.2.8 Miscellaneous Storage

The LSRF shall provide adequate storage for various small objects, many of which might be packaged into kits. These include:

- a. Hematology
- b. Fluid handling
- c. Plant tools
- d. Surgery/dissection
- e. Others

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3.0 SYSTEM REQUIREMENTS

3.1 GENERAL REQUIREMENTS

The system requirements for the IOC life sciences (non-human) laboratory and transition from a partial module (shared) laboratory to a full module laboratory are included.

3.1.1 Laboratory Accommodations

3.1.1.1 Laboratory accommodations shall make maximum use of common hardware.

3.1.1.2 Laboratory accommodation designs shall be supplemental to the common module.

3.1.1.3 Design provisions shall be made for bio-isolation to provide positive isolation of the plant/animal vivarium from crew occupied areas of the Space Station.

3.1.1.4 The LSRF module shall be located within the Space Station elements, compatible with minimizing crew through traffic.

3.1.2 Experiment Provisions

3.1.2.1 The LSRF system shall provide standard utility interfaces for experiment equipment.

3.1.2.2 The LSRF system shall provide for easy changeout of experiment equipment on-orbit.

3.1.2.3 The LSRF module shall provide for experiment monitor and control.

3.1.3 Ground System

Facilities, equipment, and capability shall be provided to perform the following functions in support of the LSRF.

3.1.3.1 The ground system shall provide for processing and servicing the LSRF module for launch in the National Space Transportation System (NSTS) orbiter.

3.1.3.2 The ground system shall provide for the well being and care of live specimens.

3.1.3.3 The ground system shall provide for the preparation of live specimens for transport to the Space Station with the logistics module.

3.1.3.4 The ground system shall provide the capabilities to process and care for live specimens returning from the Space Station in the logistics module.

3.1.3.5 The ground system shall provide the capability for storing and processing sacrificed specimens returned for analysis.

3.1.4 Logistics Resupply

The LSRF resupply shall be supported by the Space Station logistics module transported to and from orbit by the NSTS orbiter. Resupply will nominally occur every 90 days.

The general logistics cargo scenario is:

- a. Up cargo is delivered in a logistics module that will be berthed to the Space Station for 90 days.
- b. Upon arrival of the resupply logistics module, the return module has been loaded and secured for down transport on the orbiter.
- c. Live specimens transported to orbit must be removed immediately upon arrival on-orbit.
- d. 90 day expendables may be stored in the logistics module.
- e. As the 90 day period progresses the logistics module is configured to a down cargo mode and is progressively loaded with equipment, waste, and ORU's is for return.

3.1.4.1 Live specimen transport in the logistics module shall provide bio-isolation protection between the live specimen environment and the logistics module atmosphere.

3.1.5 Natural and Induced Environments

3.1.5.1 Natural Environment Design Criteria

The Space Station modules shall be designed to meet all performance requirements for operations in the natural environmental conditions, e.g., orbital density and composition, contamination, radiation, meteoroids, thermal, pressure, physical constraints,

prescribed in applicable document NASA TM-82585 "Natural Environment Design Criteria for the Space Station Definition Phase". The Space Station module shall be designed with minimal sensitivity to environment conditions during assembly, checkout, launch and on-orbit operations.

3.1.5.2 Induced Environment

The Space Station outfitted modules shall be designed to meet all performance requirements while operating in the induced environments (electromagnetic, vibration, acoustic, shock, linear acceleration, temperature, reduced atmosphere, contamination, and radiation) of the checkout, launch, and orbital locations.

3.1.5.3 Induced Contamination Environment

The contamination environment shall be reflected in the selection, design, location and operation of the Space Station and all Space Station modules operated in its vicinity such as in the berthing, deployment and retrieval of other spacecraft. Contaminants from internal and external sources shall be evaluated and monitored. The final design shall provide for limiting contamination from all sources. All experiment payloads shall be designed and grouped for a mission such that they will not contaminate each other or any of the critical subsystems.

- a. External. Overall Space Station and Space Platforms contamination environment requirements are listed in figure 3.1.5-1 in terms of molecular, particulate, deposition parameters, background light levels and electric and magnetic field intensities. These requirements apply to regions of the Space Station and platforms where sensitive instrumentation is located and during quiescent periods (no berthing, docking, OTV, OMV, EVA activities, etc.) During activity periods, environmental perturbations must be transient and not preclude or significantly delay programmed scientific experiments.
- b. Internal. Contamination control shall consider all Space Station operations, crew implications and other external interfaces.
 1. Toxicology. Design of the toxicology and contamination detection and control system shall address offgassing from non-metallic thermodecomposition products, metabolic products, and small particulate matter.
 - (a) The Space Station shall have means for detection and control of internal contamination of the atmosphere.

<u>Parameter</u>	<u>Limits Not To Be Exceeded</u>
Column Densities	10^{11} molecules/cm ² for H ₂ O + CO ₂ 10^{13} molecules/cm ² for O ₂ + N ₂ 10^{10} molecules/cm ² for other sources
Background Light Levels	Should not significantly exceed normal background sky brightness from natural occurring sources.
Particle Release	Not to exceed 1 particle per orbit greater than 5 microns size per 10^{-5} steradian field of view as seen by a 1 meter diameter telescope aperture.
Deposition of Generated Matter as a Result of Direct or Atmospheric Scattering	Deposits of contaminants originating from Space Station modules shall not significantly degrade the performance of the items on which these deposits occur. In the region of optical instruments, deposits shall not exceed 100 Angstroms/yr for surfaces at 298°K, and 40 Angstroms/yr for surfaces at 4°K.
Electric Field Intensity	Not to exceed an electric field strength of 0.1 V/m (DC, AC 1 MHz) or 0.001 V/m (AC 1 MHz) at a distance of 10 m from a single point source (excepting intentional sources).
Magnetic Field Intensity	Not to exceed a field intensity specified for equipment in MIL-STD-461B and not to exceed 7.958 amps/m at any frequency.

Note: For simplicity, units are expressed in SI system only.

Figure 3.1.5-1. Space Station and Platform External Contaminants Criteria (Quiescent Operation)

- (b) All internal habitable volumes shall have a control system to provide adequate air circulation and filtration to control air particulate levels to less than $353,000/\text{m}^3$ ($10,000/\text{ft}^3$) for particles greater than 0.5 microns in size.
- (c) Means shall be provided for detection of trace gas levels, the microbial load, and the particulate load in the Space Station atmosphere. Means shall also be provided for alerting the crew and then implementing corrective action if contaminants are approaching an out of limits level.
- 2. Microbiology. The "STS Microbial Contamination Control Plan", JSC-16888 Rev. A, shall be applied to the microbial contamination control with appropriate revision for inflight detection. To prevent microbiological cross-contamination, provisions shall be made to isolate crew members and non-human biological specimens.
- 3. Radiation limits
 - (a) Ionizing radiation. The Space Station shall provide necessary protection to ensure that the maximum tolerable dosage limits of the equipment and crew are not exceeded. The maximum exposures for each crew person are shown in figure 3.1.5-2. Sufficient protection shall be provided to allow continuous crew occupancy for up to one year. Radiation monitoring capabilities shall be provided.

3.1.6 LSRF Lifetime

3.1.6.1 Operational Lifetime

The LSRF shall have the ability to remain operational indefinitely through periodic inspection, maintenance, and replacement of components.

3.1.6.2 Safe Disposal

Provisions shall be made for the safe disposal of the LSRF module.

3.1.7 Modular Design Commonality Growth

The LSRF shall be designed to facilitate system growth through use of modular and subsystem design. The LSRF shall employ common hardware, software and standard interfaces which optimize benefit to the SSP.

<u>Constraints in REM</u>	<u>Bone (5 cm)</u>	<u>Skin (0.1 mm)</u>	<u>Eye (3 mm)</u>
1 Yr. Avg. Daily Rate	0.2	0.5	0.3
30 Day Maximum	25.0	75.0	37.0
Quarterly Maximum	30.0	80.0	40.0
Yearly Limit	60.0	170.0	85.0
Career Limit	200.0	600.0	300.0

REM - Radiation absorbed dose in RAD's times a quality factor (q) to account for the different relative biological effectiveness (RBE) of different radiations. For planning purposes, $q = 1.2$.

NOTE: This table expressed in SI units only due to common usage by the discipline.

Figure 3.1.5-2. Ionizing Radiation Exposure Limits

3.1.8 Technology Accommodations

The LSRF shall be designed to accommodate the incorporation of new technology as appropriate to optimize benefits to the program.

3.1.9 Automation

3.1.9.1 Automation shall be employed commensurate with the minimizing menial crew tasks in tending the laboratory vivarium functions.

3.1.9.2 Automation shall be considered for application to laboratory functions where a greater degree of precision and control can be achieved with the associated improvement in experiment results and minimizing of crew task requirements.

3.1.10 Maintainability

The LSRF subsystem and software shall be designed:

- a. To facilitate on-orbit and ground maintenance, inspection, and repair with maintenance performed on-orbit to the Orbital Replaceable Unit (ORU) level.
- b. Such that all reasonable failures or damage is restorable or repairable.
- c. To provide for monitoring, checkout and fault detection, and isolation to the ORU level without requiring removal of ORU's.
- d. To be capable of undergoing maintenance without the interruption of critical services and with minimum interference with other LSRF operations.
- e. To provide adequate clearance and accessibility to facilitate maintenance.
- f. To be compatible with EVA operations and to facilitate maintenance using remote manipulator devices, where applicable.
- g. Such that maintenance does not introduce hazardous or destructive conditions.
- h. Such that preventive and corrective maintenance activities for the LSRF minimizes the use of available crew time.
- i. Such that each LSRF element can be replaced at any time during the life of the Space Station.
- j. Replacement of an ORU shall not require removal of other ORU's to gain access.

3.1.11 Reliability

Reliability programmatic requirements shall be as specified in SSP (J8400001), "Product Assurance Requirements for the Space Station Program." Reliability design requirements for the SSP are as follows:

3.1.11.1 Failure Tolerance

Safety critical and mission critical subsystems are those whose function, if lost, would produce a condition endangering on-board personnel or prevent the accomplishment of a critical mission objective. Safety and mission-critical subsystems shall be designed to be fail-operational/fail-safe/restorable, as a minimum (except primary structure and pressure vessels in rupture mode and premature firing of pyrotechnics). This criteria applies during all operational phases except initial assembly and maintenance. For applicable subsystems, some degraded performance following the first failure is not precluded by the fail-operational/fail-safe requirement. During assembly and maintenance, critical LSRF subsystems shall be fail-safe as a minimum. Other LSRF subsystems and ground support hardware shall be designed to be fail-safe/restorable. Subsystems in pressurized modules shall be able to return to normal operation after the module has lost pressure on-orbit and been repressurized.

3.1.11.2 Redundancy

- a. Redundancy verification. Redundant functional paths of subsystems shall be designed to permit verification of their operational status in flight without removal of ORU's.
- b. Redundancy management. LSRF subsystem design shall provide redundancy management and redundancy status to the flight or ground crew, as applicable. Safety and mission critical subsystems shall be designed such that no single instrumentation failure shall cause the loss of a redundant functional path.

3.1.11.3 Failure Propagation

Subsystem design shall be such that one failure does not cause additional failures.

3.1.11.4 Separation of Redundant Paths

Alternate or redundant functional paths shall be separated or protected such that any event which causes the loss of one functional path will not result in the loss of the alternate or redundant functional path(s).

3.1.12 Safety

The safety programmatic requirements shall be as specified in "Product Assurance Requirements for the Space Station Program", (J8400001). The LSRF and ground systems shall meet the safety design requirements specified herein.

The following safety requirements are applicable to all SSP systems, subsystems, and operations. These requirements apply under worst-case natural and induced environments.

3.1.12.1 Order of Design Precedence

The LSRF design shall reflect the following order of precedence: (1) elimination of hazards by removal of hazardous sources and operations by appropriate design measures; (2) prevention of hazards through the use of safety devices or features; (3) control of hazards through the use of warning devices, special procedures, and/or emergency devices; and (4) minimization of hazards through a maintainability program and adherence to an adequate maintenance and repair schedule(s).

3.1.12.2 General Safety Requirements

- a. Safing. The following capabilities shall be provided by the Space Station:
 1. Detection, containment, and control shall be provided for emergencies such as fires, toxic contamination, depressurization, malfunction of mechanical systems and rotating equipment, or structural damage. Specific procedures shall be provided for each emergency to restore a safe operating condition.
 2. Isolation of any module containing confined hazardous or toxic materials from the remainder of the Space Station. Emergency conditions requiring isolation of a module shall be defined on a case-by-case basis.
- b. Safe haven. The Space Station shall be able to tolerate any single credible failure, including the complete functional loss of any one module, during all phases of the life of the Space Station.

In the event of such a failure, the Space Station shall provide the following capabilities for 28 days beginning at any point in the resupply cycle:

 1. Habitable conditions for the crew in the remaining modules; including atmosphere, food, water, waste management, health maintenance, personal hygiene, sleeping provisions, communications, and command/control and fire suppression.
 2. Access to habitable conditions by all crew members from any point in the Space Station without EVA.
 3. Orbiter berthing capability for crew rescue.
- c. System failure notification. All failures of critical systems shall be annunciated to the flight and/or ground crew.

d. Pressure vessels

1. Storage containers. Potentially explosive containers shall be located outside of habitable areas, shall be isolated and protected so that failure of one will not propagate to others, and shall be designed to leak-before-rupture. Specific safety requirements and handling procedures shall be provided for all potentially hazardous materials.
 2. Pressurized modules. All pressurized modules shall be designed to leak-before-rupture criteria. A wall puncture due to an accident or collision shall not result in rupture. Conservative factors of safety shall be provided where critical single-failure-point modes of operation cannot be eliminated.
 3. Pressurized lines and fittings. Pressurized lines and fittings shall meet the ultimate factors of safety specified in paragraph 3.2.1.2. Other pressure system components not considered pressure vessels, lines, and/or fittings shall have an ultimate factor of safety equal to or greater than 2.5.
 4. Accessibility. All walls, bulkheads, hatches, and seals where integrity is required to maintain pressurization shall be accessible for inspection, maintenance, or repair by shirt-sleeved crew members.
 5. Depressurization capability. Systems, subsystems, or equipment located in LSRF pressurized volume designed to withstand decompression and repressurization shall be capable of tolerating the differential pressure and depressurized condition without resulting in a hazard.
- e. Hazardous accumulation of fluids. Provisions shall be made to prevent hazardous accumulations of gases or liquids within the LSRF. Detection, monitoring, and control of hazardous gases or vapors shall be required in critical areas and closed compartments.
- f. Drains, vents, and exhaust ports. Drains, vents, and exhaust ports shall prevent fluids, gases and/or vapors, and flames from creating hazards to personnel, vehicles, or equipment.
- g. Exposed surface temperatures. Exposed surfaces within modules shall not exceed a temperature of 45°C (113°F) (with a design goal of 42°C (108°F)) and a low temperature less than 16°C (61°F).
- h. Battery location design. Batteries shall be isolated and/or provided with safety venting systems and/or explosion protection. In addition, thermal control and charging/discharge protection for batteries shall be provided, where applicable.

- i. Exposed power leads. The crew shall not be exposed to electrical power leads. Ground-fault protection shall be provided for circuitry or power distribution busses directly accessible by the flight crew.
- j. Fire suppression. Capability shall be provided for detecting and extinguishing any fire in LSRF Module volumes. Interior walls and secondary structures shall be self-extinguishing. Fire extinguishers shall be compatible with the ECLSS and shall be non-toxic and not produce toxic by-products.
- k. Emergency equipment. Emergency life support, damage assessment, and medical equipment shall be readily accessible to the crew.

3.1.12.3 Materials

The Space Station materials requirements for hazardous materials, flammability, and offgassing are as follows:

- a. Hazardous materials
 - 1. General. The use of hazardous materials shall be minimized; those used shall meet the applicable requirements specified in NHB 8060.1B, "Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials Used in Environments that Support Combustion".
 - 2. Material radiation effects. Materials and components subject to insidious degradation in the Space Station ionizing environment shall not be used where that degradation can cause or contribute to any crew hazards.
 - 3. Mercury. The use of mercury or its compounds shall be restricted.
- b. Habitable volume materials. Materials which are used in LSRF modules shall meet the requirements of NHB 8060.1B.
- c. Flammable materials. Flammable materials exposed to the ambient atmosphere of LSRF module's volume shall be separated to prevent flame propagation paths. Similarly, separation of flammable materials from potential ignition sources is required to the maximum extent possible. Minimizing the use of flammable materials shall be the preferred means of hazard reduction. Materials are considered to be nonflammable or self-extinguishing if they meet the applicable flammability requirements of NHB 8060.1B.
- d. Materials offgassing. Materials used in the LSRF module shall meet the requirements of NHB 8060.1B, for toxic outgas constituents in the lowest operating pressure to which they may be exposed.

- e. Materials contamination. Equipment or materials sensitive to contamination shall be handled in a controlled environment. Fluids and materials shall be compatible with the combined environment in which they are employed.
 - 1. Materials exposed to space vacuum shall meet the requirements of SP-R-0022A for vacuum outgassing.
 - 2. Metallic materials which are exposed/used in the habitable volumes shall be selected and controlled by the criteria of MSFC Specification 522A "Design Guidelines for Controlling Stress Corrosion Cracking".
 - 3. Exterior materials shall consider atomic oxygen effects.

3.1.12.4 Malfunction Control

- a. Override capability. The crew must be able to override any automatic safing or switchover capability of functional paths. All overrides shall be two-step operations with positive feedback to the initiator that reports the impending results of the override command prior to the acceptance of an execute command. Separable functional paths shall be used to prevent single failures from causing both an unintended auto switchover and the inability to override it.
- b. Command/control redundancy. Redundant accommodations for complete command and control of the Space Station shall be provided in separate pressurized volumes. Functions to reestablish pressure in a module shall be operable by pressure-suited crewmembers.

3.1.13 Quality Assurance

Quality assurance program requirements for the SSP are defined in SSP reference document, "Product Assurance Requirements for the Space Station Program," (J8400001).

3.1.14 Human Productivity

The LSRF environment shall optimize the productive activities of the crew through the application of advanced human factors engineering practices and the appropriate use of automated subsystems to relieve the crew of routine tasks.

3.2 FUNCTIONAL AND DESIGN REQUIREMENTS

3.2.1 Structures

3.2.1.1 Functional Requirements

The LSRF outfitting designs shall be of adequate strength and stiffness to resist without failure all imposed environmental loads including ground testing, ground transport, launch, orbital operations, and normal and abort landings.

The functional requirements for the LSRF are as follows:

- a. Provide laboratory equipment mechanical installation design and structural support.
- b. Provide laboratory storage accommodation.
- c. Provide bio-isolation design features and installation.
- d. Provide experiment equipment installation interchangeability through modularity and commonality.

3.2.1.2 Design and Performance Requirements

- a. Fail-safe. The primary, secondary, and transport structure shall be designed so that failure of a single structural member shall not degrade the strength or stiffness of the SSPE to the extent that its crew or mission is placed in jeopardy or result in a catastrophic failure of the SSPE.
- b. Human factors. Interior secondary structure shall be designed to meet the requirements of paragraph 3.2.7. Closeout structure will be used where practical to reduce the possibility of items becoming lost in the zero-g environment. Partitions, walls, and closeout structure, as appropriate, shall be designed to be rearranged on-orbit to accommodate LSRF growth and maintenance access. A common system for visual reference shall be used at activity stations throughout the SSP. The connections of utilities residing in and attached to secondary structure shall be designed to be made and broken with minimal crew effort and time. Attached hardware shall permit relatively easy equipment reconfiguration.
- c. Margin/factors-of-safety. All structures shall have positive margins of safety (MS) for all load conditions. The following relation defines MS:

$$\text{Margin of Safety (MS)} = \left[\frac{\text{Allowable Load}}{\text{Limit Load} \times \text{Factor of Safety (FS)}} \right] - 1.0$$

Factors of safety are assumed multiplicative constants applied to maximum expected or limit loads that occur during any phase of the hardware from

manufacture throughout its operational life to account for uncertainties in load definition, material properties, dimensional discrepancies, etc.

The design of structure of the LSRF shall use the appropriate factors of safety defined in figure 3.2.1-1.

- d. Fracture control. The structure of the LSRF shall use appropriate fracture control requirements defined in JSC-19649, "Space Station Fracture Control Plan".
- e. Standard structural interfaces and commonality. The structure of the SSPE's shall be designed with standard interfaces between components comprising the modules such as end caps and cylindrical sections, between primary structure and secondary structure, and between subsystem components and their attachment to structure. The LSRF shall employ standard fasteners and tools for structural and mechanical attachments standard with other SSPE's. Commonality of structural interfaces shall be maximized.
- f. Thermal distortion. Structural design shall minimize thermal distortion.
- g. Atmosphere leakage. Total atmospheric leakage from each pressurized module shall not exceed 0.227 Kg (0.5 lbs) per day maximum. As a design goal, leakage shall not exceed 0.045 Kg (0.1 lb) per day.

3.2.1.3 Materials

Materials will be selected on the basis of functional acceptability and suitability, extended life, technological maturity, manufacturability, inspectability, contamination characteristics, specific strength, compatibility, availability, cost, and safety.

3.2.2 Mechanisms

3.2.2.1 General

- a. The LSRF mechanisms shall be designed to be tested prior to their on-orbit use through ground-based testing and/or orbital demonstrations.
- b. Mechanisms shall be designed as independent assemblies with distinct and definable interfaces. Mechanisms shall be designed, where practical, to be removed and replaced on-orbit.
- c. Where automated actuation is required, electromechanical actuation systems shall be the primary candidate.

<u>Components</u>	<u>Minimum Factors of Safety (FS) Ultimate</u>
General structure	1.5 *
Pressurized manned compartments	2.0
Pressure vessels	1.5
Pressurized lines and fittings	
Less than 1.5-in.-diameter	4.0
1.5-in.-diameter or greater	2.0
Tempered or mechanically precompressed panes	Initial FS 3.0 **

* General structure shall be designed with a yield factor of safety (FS) no less than 1.1. Protoflight hardware must be designed to not yield when subjected to validation loads.

** Glass shall be designed such that the limit tensile stresses on the glass do not exceed the surface compression of the glass, and thus the glass does not lose strength with time.

Figure 3.2.1-1. Factors of Safety

3.2.3 Electrical Power

3.2.3.1 Functional Requirements

The functional requirements for the LSRF are as follows:

- a. Provide electrical power distribution and control.
- b. Provide electrical power conditioning and protection.
- c. Provide laboratory lighting and control.

3.2.3.2 Design and Performance Requirements

- a. Power protection shall be provided for the power sources against overloads or faults in the Space Station distribution and LSRF subsystems. Power protection shall be provided for distribution functions against overloads. For the customer loads, power protection shall be provided to prevent adverse impact or damage to other LSRF subsystems.
- b. The grounding scheme shall be a single point ground.
- c. Diverse routing of redundant wiring and location of redundant components shall be implemented. The design shall preclude a single open circuit causing loss of a primary power. All wiring shall be short circuit protected at the sources with replaceable or resettable devices or be current limited.
- d. A standard electrical power interface shall be provided at each experiment rack to facilitate equipment interchangeability.

3.2.4 Thermal

3.2.4.1 Functional Requirements

The thermal control subsystem shall provide laboratory equipment heat transport to the thermal bus interface.

3.2.4.2 Design and Performance Requirements

- a. The thermal design shall easily interface with equipment, modules, and payloads. As a design goal, the interface shall not require making and/or breaking fluid connections for maintenance and refurbishment or experiment installation.
- b. For attached payloads, thermal acquisition and transport to the central system shall be provided at the payload attachment interface.
- c. A method for detecting, locating, isolating, and repairing leaks within the system shall be provided.

3.2.5 Data Management System (DMS)

3.2.5.1 Functional Requirements

The DMS shall provide the following functions:

- a. Provide experiment monitoring and control.
- b. Provide data storage and retrieval.
- c. Provide video transmission and storage.
- d. Provide audio distribution and storage.
- e. Provide laboratory subsystems monitor and control.

3.2.5.2 Design and Performance Requirements

- a. A data workstation shall be provided. It shall interface with the data bus and be fully interactive with the SSP data management system.
- b. Checklists and procedures will be stored in the SSP DMS and accessed through the data workstation. A capability to update the checklists and procedures with ease and control is required.
- c. The DMS shall support a general purpose programming language.

3.2.6 Environmental Control and Life Support System (ECLSS)

3.2.6.1 Functional Requirements

The LSRF ECLSS functions include air pressure and composition control, laboratory temperature and humidity control, air revitalization, water management and waste management. In implementing these functions, the ECLSS shall embody regenerative concepts to minimize the use of expendables.

- a. Air pressure and composition control. Atmospheric pressure and composition control functions shall provide a method of monitoring and regulating the partial pressure and total pressure of gases for supply to the plants and animals and to the crew. A capability for fire suppression shall also be provided.
- b. Air temperature and humidity control. The temperature and humidity shall be controlled in the plant and animal enclosures and in the cabin air.
- c. Air revitalization. Atmospheric revitalization systems shall regenerate the module atmosphere, as necessary, to provide a safe and habitable environment for the crew and a habitable environment for the plant/animal enclosures. Monitoring and control of contaminants shall be provided.
- d. Water management. The collection, processing, and dispensing of water to meet LSRF experimental needs shall be accommodated. Pretreating of waste water to

prevent chemical breakdown and microbial growth prior to processing shall be provided. Post treatment systems and a monitoring system to ensure proper water quality shall also be provided to control and monitor contaminants prior to water use.

- e. Waste management. A means of collecting, processing, and disposal of laboratory wastes shall be provided.

3.2.6.2 Design and Performance Requirements

- a. Atmospheric pressure and composition control.

1. The ECLSS shall have the capability to accommodate atmospheric leakage of each module up to 0.23 Kg/day (0.5 lb/day).
2. The capability shall exist for dumping the atmosphere of a pressurized module overboard in the event of contamination or fire within that volume.

- b. Module temperature and humidity control.

1. The respirable atmospheric composition, temperature/humidity variation, and ventilation levels provided by the ECLSS shall meet the requirements in figure 3.2.6-1A and figure 3.2.6-1B.
2. Crewmembers shall be able to modify temperature and humidity within specified ranges inside the individual modules.
3. The ECLSS shall interface with the thermal control subsystem for removal of waste heat from the pressurized modules.

- c. Air revitalization.

1. Electrolysis of recovered water shall be the primary source for oxygen.
2. The nitrogen supply for the initial station will be provided by storage and resupply.
3. The LSRF CO₂ removal and plant CO₂ supply processing system shall be determined by a tradeoff study.
4. Planned overboard venting of gases shall be limited to those gases that will not degrade the performance of either subsystem components exposed to space or customer facilities and experiments. Gas venting that is permitted shall be minimized, controlled, and nonpropulsive.

- d. Water management.

1. Potable water for the animal test specimens source shall be determined by tradeoffs.
2. Water recovered from laboratory cleaning tasks shall be processed for reuse.

<u>PARAMETER</u>	<u>UNITS</u>	<u>OPERATIONAL</u>	<u>90-DAY DEGRADED (1)</u>	<u>22-DAY EMERGENCY</u>
CO ₂ Partial Press	mmHg	3.0 max	7.6 max	12 max
Temperature	deg F	65-75	60-85	60-90
Dew Point (2)	deg F	40-60	35-70	35-70
Ventilation	ft/min	15-40	10-100	5-200
O ₂ Partial Pressure (4)	psia	2.7-3.2	2.4-3.8	2.3-3.9
Total Pressure (5)	psia	10.2 or 14.7	10.2 or 14.7	10.2 or 14.7
Dilute Gas	----	N ₂	N ₂	N ₂
Trace Contaminants (8)	mg/m ³	TBD	TBD	TBD
Micro-organisms	CFU/m ³ (6)	500(7)	750(7)	1000(7)

**FIGURE 3.2.6-1A - RESPIRABLE ATMOSPHERE
(CUSTOMARY UNITS)**

<u>PARAMETER</u>	<u>UNITS</u>	<u>OPERATIONAL</u>	<u>90-DAY DEGRADED (1)</u>	<u>22-DAY EMERGENCY</u>
CO ₂ Partial Press	N/m ²	400 max	1013 max	1600 max
Temperature	°K	291.5-297.1	288.8-302.6	288.8-305.4
Dew Point	°K	277.6-288.8	273.9-294.3	273.9-294.3
Ventilation	m/sec	.076-.203	.051-.508	.025-1.016
O ₂ Partial Pressure (4)	N/m ² x10 ³	18.6-22.1	16.5-26.2	15.0-26.9
Total Pressure (5)	N/m ² x10 ³	70.3-101.4	70.3-101.4	70.3-101.4
Dilute Gas	----	N ₂	N ₂	N ₂
Trace Contaminants (8)	mg/m ³	TBD	TBD	TBD
Micro-organisms	CFU/m ³ (6)	500(7)	750(7)	1000(7)

NOTES:

- (1) Degraded levels meet "fail operational" criteria.
- (2) Relative humidity shall be within the range of 25-75 percent.
- (3) Minimum.
- (4) In no case shall the O₂ partial pressure be below 2.3 psia, or the O₂ concentration exceed 25.9 percent of the total pressure at 14.7 psia or 30 percent of the total pressure at 10.2.
- (5) All systems shall be compatible with both 10.2 and 14.7 psia total pressure.
- (6) CFU- Colony forming units.
- (7) These values reflect a limited base. No widely sanctioned standards are available.
- (8) Based on NHB 8060.1B, (J8400003).

**FIGURE 3.2.6-1B - RESPIRABLE ATMOSPHERE
(SI UNITS)**

- e. Waste management. Methods to efficiently process the solid wastes into inert products for easy disposal shall be provided.

3.2.7 Habitability/Man Systems

This requirements paragraph contains all crew systems and integration requirements. Portions of the hardware implementation of these requirements shall be the responsibility of the appropriate subsystem.

3.2.7.1 Systems Integration

Areas involving crew systems and crew support shall be designed according to standards of interior design and decoration to facilitate human productivity. Qualified colors, textures, and nonhazardous paints in accordance with Federal Standard 595, and MSC SC-M-0003, shall be consistent with the functions intended for each area, and they shall be used to provide visual orientation cues (local vertical and emergency exit cues), equipment stowage location cues, use location aids, aesthetic variety, and contrast for the crews. Visual local-vertical orientation shall be provided in crew occupied areas of the Station. Accommodations and facilities shall be designed to the zero-g neutral body posture, traffic patterns, congestion avoidance, cleaning, and ease of maintenance. Layout of facilities shall be supported by traffic flow analysis and simulation. Functional group interrelationships shall be a prime consideration in the basic arrangement. Crew facilities and equipment shall be designed to support reconfiguration, growth, and update. The LSRF interior shall be devoid of all sharp-edged surfaces.

- a. Standardization. Crew interfaces and associated equipment shall be standardized throughout the Space Station. Crew stations with multiple uses shall be used. Markings and labels shall utilize international standards/symbols throughout all modules.
- b. Antropometric requirements. The design of crew subsystems shall consider using the 5th-percentile oriental female to 95th-percentile American male anthropometric strength and size measurements adjusted for 30-year growth trends from the baseline estimate year 1985 extrapolated to the year 2000, as defined in NASA RP 1024, "Anthropometric Source Book", Volume I. Designs shall consider the known 5th to 95th percentile range of crew biomechanical limb segment orientations in weightlessness as described in NASA RP 1024, and MSFC Std. 512A, or other appropriate documentation. Where designs cannot reasonably accommodate this range, recommendations shall be made to utilize alternative solutions.

c. Lighting.

1. The lighting system shall provide interior illumination of intensity and types to facilitate human productivity. Minimum lighting levels and direction of illumination shall be specified in all areas and for specific tasks, consistent with the latest versions of JSC-19517; JSC-SC-L-0002A; and MIL-STD-1472. Supplemental portable lighting shall be provided.
2. Particular care shall be exercised to prevent shining directly into the eyes of the crewmember, shadowing, high contrast, glare, and excessive light. Light levels shall consider optimum light contrast for CRT viewing.
3. "Three-way" light switches and variable intensity controls shall be placed in convenient locations throughout the Space Station.
4. Night light route locators and switch illumination shall be placed in areas that are frequently darkened.
5. All module berthing ports shall have 53 lm/m^2 (5 footcandle) minimum illumination for specular surfaces and 107 lm/m^2 (10 footcandle) minimum illumination for diffusing surfaces.

- d. Displays and controls. Multifunctional displays and controls shall be used. The following shall be designed to facilitate human productivity: character size, display brightness and contrast, auditory characteristics; control size, direction of motion, and types of controls; display format characteristics such as use of color, color coding, and graphic versus textual display; feedback to the operator from controls, including tactile, visual, and auditory feedback requirements. Emergency operation of controls shall have a shape, texture, and location that is readily identifiable in the dark. The use of manually operated switches shall be minimized. Controls shall be protected against inadvertent operation.

e. Stowage areas.

1. Stowage, retrieval, and restowing of all required crew support items shall be major factors in the interior arrangement of the LSRF. The various stowage items shall be located as close to their use location as is practical. Color graphics shall be utilized as an aid in crew location of stowage items. Short descriptions of all workstation supplies including inventories, use rates, remaining items, and possible substitutions will be maintained on the onboard computer and be accessible from any Space Station control console. Modular stowage lockers shall be incorporated into the overall interior arrangement of the space station. Common design latching devices shall be utilized for all stowage areas.

2. Equipment stowage provisions and restraints shall allow for easy identification of the stowed item prior to removal. Drawers and cabinets shall be equipped with suitable restraints to allow access, removal, and restowage of equipment. Drawer stowage devices shall be equipped with means to prevent small items from drifting. Stowage areas shall be compartmented to aid in the control of equipment during crewmembers stowage and removal of equipment. Temporary restraint of equipment shall be available near stowage areas and use locations.
- f. Mobility and restraint. Crew and equipment restraints and location aids shall be provided in every module. Major hatches, doors, and other passageways within a module shall facilitate crew mobility with a minimum of difficulty, avoiding major unusual body reorientations. The size and shape of such openings should fully recognize and exploit the crew neutral body position range in weightlessness, and the transfer of hardware by the crew member. Restraint systems will be designed for workstations that reflect the requirements analysis and sound human factors engineering for zero-g body postures. The restraint system must be adjustable to accommodate the specified anthropometric requirements. Comfort of the restraint system shall allow for 4-hour uninterrupted use. Both permanent and portable restraint techniques are required. When not in use, restraint systems shall be stowable so as to leave the aisle completely clear and with no surfaces protruding.
 1. Locomotion.
 - (a) Handholds and pushoffs shall be incorporated into the interior arrangement of the module to facilitate the crew mobility/stability. Design passageways and locomotion aids shall consider the neutral body positions in weightlessness and the inherent freedom associated with weightlessness.
 - (b) Traffic routes for translation shall be used to consider frequency of use and the best combinations of uses of the volumes considered for the specific traffic route. The minimizing of travel time and effort and the provision of safe, controlled translation shall also be considered.
 - (c) Equipment located in traffic routes and workstation areas shall be designed to accommodate crew movement. Items that require moving in the station shall have build-in handles and/or structural or mechanical parts suitable for gripping. Display/control surfaces shall have protection against inadvertent crew/equipment impact.
 - (d) A clear zone shall be established contiguous with each hatch and bulkhead opening, requiring all surfaces be free of hardware protrusions, sharp corners and edges, and recesses or holes. Such translation traffic routes

shall not interfere with the working, eating, sleeping, or relaxation of crewmembers.

- (e) Hatches, interconnecting tunnels, passageways, etc., shall be no less than 1.27 m (50 in) internal diameter and shall not be surrounded by structures which cause unusual body contortions or major reorientations to accomplish passage. Hatches shall be capable of supporting either an open or closed hatch mode with manual control requiring a maximum of 30 seconds.
- 2. Crew restraints. A positive versatile body restraint system shall be provided for crewmember use throughout the LSRF. The system shall be fully adjustable, permit a full range of orientations about the attachment point(s), permit completely free use of both hands and upper torso for manipulative tasks, and shall minimize or eliminate supplemental muscle tension or foot/leg reactions against auxiliary surfaces to hold effective working attitudes. Handholds/handrails shall be strategically located to assist entry/exit at all workstations. The restraint system architectural interface shall be common for all modules and shall utilize architectural hardware tolerant of and accommodating to the restraint device's mating receptacle(s). The restraint system shall be capable of on-orbit cleaning.
- 3. Equipment restraints. Equipment restraints shall be provided to anchor every item of use that is not permanently attached to the station.
- g. Housekeeping. The LSRF shall be designed to minimize the time required for adequate and verifiable cleaning. All areas shall be conveniently cleanable and maintainable with provisions for trash compaction, biological stabilization, stowage, etc. The cleaning equipment and supplies shall be accessible to and usable by the crews. Standards will be provided for the safe use of bacteriocides on open surfaces and other potential contaminants inside the LSRF. All trash shall be compacted and collected at convenient, designated locations. Trash shall be treated to prevent it from producing gas or odors. Special housekeeping requirements for laboratory and experimental areas (e.g., animal facilities) shall be accommodated.
- h. Odor control. Odor shall be controlled through the use of adequate body waste collection and disposal and through the treatment of biologically active trash. These methods shall be supported through adequate means of atmospheric revitalization and airflow.
- i. Internal contamination detection and control. Contamination control shall consider all Space Station operations, crew implications and other external interfaces.

Toxicology, microbiology, radiation and vibro-acoustics and limits are specified in section 3.1.5.3.6.

3.2.7.2 Crew Stations

- a. Work Stations. A crew station shall be defined as any location in the Space Station where a dedicated task or activity is performed. A work station is a crew station which is exclusive of recreation, personal hygiene, food preparation, dining, house-keeping, and other off-duty activities. Accepted human factors engineering practices and criteria shall be used to design the human interface with the individual work stations. A thorough analysis of the requirements shall be done for each work station to determine the task, operator activities, level of automation, tools, equipment, etc. necessary to meet the baseline safety requirements for the Space Station and will provide utility power. Work stations equipped to perform identical tasks (e.g., station housekeeping functions) shall utilize prime/backup logic with appropriate safeguards against dual functional path commanding. These work stations shall also satisfy the fail-safe criteria. In those work stations with a complete or partial hood, ventilation shall be provided. The air flow must be filtered prior to return to the cabin. The air stream shall be adjustable by the work station operator and not impinge directly upon the operator. The volume and velocity of the air stream shall be determined from the requirements analysis. The ventilation system shall not cause contamination of the cabin atmosphere. A specific work area shall be provided with work benches with a laminar flow condition that results in particulate level of class 100.
- b. Maintenance. The crew shall be the primary method for accomplishing scheduled, unscheduled, and contingency maintenance. Provisions shall be available for on-board maintenance to be accomplished at the problem location or at some designated maintenance location. Equipment permitting maintenance to the required levels and simple diagnosis (e.g, multimeter, etc.) of circuitry, repair of hardware, or replacement of elements shall be provided at the designated location.

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4.0 INTERFACE REQUIREMENTS

This section describes the interfaces with SSP Common Module and the SSP Logistics Module.

4.1 SSP COMMON MODULE

The LSRF Laboratory outfitting design shall supplement the common module configuration to meet the LSRF design and performance requirements.

4.1.1 All LSRF utility services will be provided by the Common Module design as follows.

- a. Electrical power
- b. Cabin ECLSS
- c. Thermal heat rejection
- d. Data Distribution
- e. Video Distribution
- f. Audio Distribution

4.1.2 Secondary structure peculiar to the LSRF outfitting design shall be designed to react structural loads through common module primary structural load paths.

4.2 SSP LOGISTICS MODULE

The SSP Logistics Module supports the continuing operation of the LSRF through transport and storage of consumables; transport of test specimens and equipment.

4.2.1 The SSP Logistics Module shall transport and store consumables required for operation of the LSRF for 90 day periods.

4.2.2 The SSP Logistics Module shall transport live specimen carrier enclosures to the LSRF for resupply and return of live animal specimens.

4.2.3 The Logistics Module shall transport LSRF freezers for return of sacrificed specimens and tissue for ground analysis.

4.2.4 The Logistics Module shall transport LSRF equipment as required to upgrade the experiment equipment complement.

4.2.5 The Logistics Module shall transport LSRF ORU's as required to maintain the laboratory equipment complement.